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(71)(72) Applicant and Inventor: HAFSTAD, Bjørn [NO/NO]; Gamle Skulehuset, N–6737 Ålfoten (NO).

(74) Agents: HÅMSØ, Borge et al.; Håmsø Patentbyrå Ans, P.O. Box 171, N–4302 Sandnes (NO).

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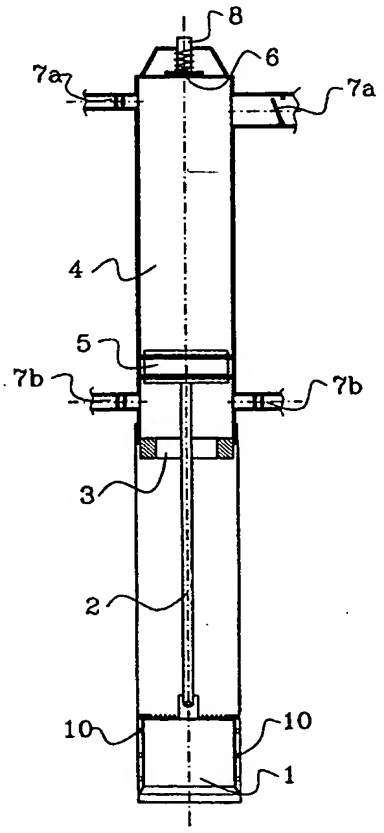
(54) Title: DEVICE AND METHOD FOR THE EXPLOITATION OF WAVE ENERGY

(57) Abstract

A system for the exploitation of wave energy is described, in which the system consists of a wave receiver (1) mounted inside a channel (2) or a wave house. Whenever the wave receiver is hit by a wave, it will be pushed inwards and in its turn force a piston (5) inwards within a first cylinder housing (4). When the air internally of the first cylinder housing reaches a predetermined pressure, a main valve (6) will open and release a certain amount of air at a predetermined pressure. The channel/wave house has an inclination in relation to the horizontal plane, sufficient for the wave receiver to be able to return to its start position by means of gravity when the wave is receding. The wave receiver may advantageously be equipped with friction reducing means (10) in the form of wheels or rollers, and may also be equipped with seals (11) to prevent water from entering past the wave receiver (1). The system may also include a second cylinder housing to adjust the distance between the piston (5) and the rear wall of the first cylinder housing. Alternatively, or in addition to the second cylinder housing, there may be one or more third cylinder housings mounted between the wave receiver and the piston (5), so that the distance between the wave receiver and the piston can be adjusted. The second and third cylinder housings are to ensure adjustment of the system to different wave heights and/or different water levels.



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DEVICE AND METHOD FOR THE EXPLOITATION OF WAVE ENERGY

The invention relates to the transformation of energy contained in sea waves into a form which is exploitable.

The sea waves contain an abundance of energy, but so far there has been no success in finding an efficient, reliable and reasonable solution for the exploitation of this energy source.

From earlier is known i.a. a plant for the transformation of wave energy into electrical power, in which the waves are guided into a channel, which is inclined in relation to the horizontal plane and which "lifts" the water of the waves up to a water reservoir which thereby has a certain drop in relation to the water level. The water of this reservoir may then be released back to the sea through one or more turbines driving one or more electric generators.

The present application is concerned with a solution consisting of two sections, of which a section 1, or a sea part, consists of one or more channels for the catching of waves.

The channels have an outer rectangular shape. Internally within the channels is installed equipment responsive to the waves, i.e. absorbing kinetic energy from the waves and transferring this energy in the form of a pressure. Section 2 consists of turbines or other suitable means for the transformation of the pressure into an exploitable form of energy, and means for storing any surplus energy. Primarily turbines are meant to be used for driving electric generators, so that the wave energy is used for the production of electrical energy.

The application teaches a method and a device for the transformation of wave energy into exploitable energy. In particular, the wave energy is transformed into a push force which is exploited further to provide air under high pressure. This air may then be used to drive one or more turbines, and/or be stored in a high-pressure storage, e.g. in the form of a pressure-tight rock hall.

To visualise the invention, reference is made to the enclosed figures 1 - 7. Figs. 1 - 3 show the sea part, section 1, in detail, while Fig. 4 is a perspective view of the same sea part. Fig. 5 shows a first alternative embodiment variant comprising a second cylinder housing, while Fig. 6 shows a third embodiment variant comprising a third cylinder housing. Fig. 7 shows a variant of the alternative in Fig. 6, in that the third cylinder housing is replaced by two cylinder housings.

A plant for the utilisation of wave energy could consist of a number of units as shown in the figures. Each unit may drive its own turbine and possibly have its own surplus storage, but normally several units will co-operate in the driving of

a turbine and share a surplus storage if such is desired. The units for catching the waves consist of a channel, a wave house 2, each, which has, in a preferred embodiment, a rectangular shape. The channel has a slight upward inclination. Inside the channel is installed a wave receiver 1 which is movable back and forth in the longitudinal direction of the channel. Further, this shovel, which may have a shape corresponding to an excavator bucket, is fitted on a piston rod driving a piston 5 in a cylinder 4 at the back. The wave receiver is preferably fitted with friction reducing means (10), such as wheels or rollers. Further the wave receiver may be provided with a seal to prevent water from entering the room behind the wave receiver. Innermost within the wave house 2 is mounted a mechanical shock absorber 3 which may be a polyurethane block. The cylinder housing 4 is further provided with a number of valves 7a and 7b which are to allow air to be lead into and out of the cylinder housing. Additionally there is a main valve 6 releasing air at a predetermined pressure for driving one or more turbines (not shown), or for the supply of air to a high-pressure storage (not shown), to be stored for later use. In association with the main valve 6 is arranged pressure control means 8 to set a desired pressure for the pressurised air supplied to the turbine(s) or to the storage(s). The valves 7b located at the rear end of the cylinder housing, i.e. the rear dead point, are formed so that it or they close whenever the piston is moved towards the rear end of the cylinder, and opens when the piston returns to the front end of the cylinder. The valves 7a located at the front end of the cylinder housing, i.e. at the end where the piston rod from the wave receiver enters the cylinder housing, may be constantly open to ensure uninhibited suction of air when the piston is moving inwards, and uninhibited venting when the piston is returning. Alter-

natively these valves may be of a kind opening and closing automatically, depending on the pressure differences across the valves. The valves 7b located at the rear end of the cylinder housing may correspondingly be of a type opening and closing automatically, depending on the pressure differences across the valves. They must be of a type that closes whenever the pressure inside the cylinder exceeds the pressure on the other side of the valve, and opens for suction when the pressure inside the cylinder drops below the pressure outside the cylinder. The main valve 6 opens when the overpressure set by means of the pressure control 8 is reached. The main valve closes automatically when the pressure inside the cylinder drops below the set overpressure, i.e. when the piston begins its return to its starting point to start another cycle.

When a wave is guided into the wave house 2, the wave receiver 1 fills with water. The water of the wave has a kinetic energy resulting in the wave receiver moving in the longitudinal direction of the wave house, and exerting a mechanical push force through the piston rod mentioned earlier, on the piston 5 inside the cylinder housing 4. When the piston starts its movement inwards within the cylinder housing, i.e. towards the rear end of the cylinder housing, the pressure in the air behind the piston increases, and the valves 7b close. The main valve 6 is closed until the piston has moved over a distance inwards within the cylinder housing, which implies that the set overpressure has been reached, whereupon the main valve opens. One of the valves 7b opens to counteract underpressure as a consequence of the movement of the piston inwards within the cylinder housing. When the piston reaches the rear dead point and the wave returns, or the wave returns before this position has been reached, the wave

receiver with axle and piston will return to its start position because of the inclination of the wave house. At the same time the main valve 6 closes so that the generated pressurised air will not leak back to the cylinder. During the return of the piston, the valves 7a open to admit air which is to be compressed by the next wave cycle.

To adjust the system for varying wave heights and also for varying water levels, a second cylinder housing 14 may be mounted inside the first cylinder housing. The second cylinder housing is in direct contact with the main valve 6 and provides adjustment of the stroke of the piston 5 so that a desired pressure may be achieved by different wave receiver pus-in lengths. Different push-in lengths occur when the wave heights changes, and will also vary with high tide or low tide. If the plant is mounted in a lake, the water level may change in particular due to flood. It is also possible to mount a third cylinder housing into the piston rod between the wave receiver and the piston 5 of the first cylinder housing 4. Possibly, two or more third cylinder housings may be mounted in parallel (Fig. 7). The second and the third cylinder housing(s) may be combined, so that the system includes a first cylinder housing 4 which provides pressurised air for further use, a second cylinder housing 14 mounted into the first cylinder housing, and one or more third cylinder housing(s) mounted into the piston rod between the wave receiver and the piston 5 of the first cylinder housing. The second cylinder housing is provided with valves along the cylinder housing to control the air pressure within the second cylinder housing and thereby adjust the volume obtainable within the first cylinder housing. This ensures that the necessary pressure for release, across the main valve 6, can be achieved by different push-in lengths of the wave receiver 1.

Alternatively or additionally, the system may be provided with one or more third cylinder housings 24 between the wave receiver and the piston 5 of the first cylinder housing. The third cylinder housing(s) is (are) used to adjust the distance between the wave receiver and the piston 5 of the first cylinder housing. This results in the system permitting adjustment to different water levels and/or different wave heights, and still being able to deliver air at a desired pressure across the main valve 6.

The pressurised air thus generated, may be exploited in various ways. For example, it may be used for driving turbines, which in turn drive electric generators, the pressurised air may be brought to a high pressure storage to be stored for later use, or it may be used in a combination in which some of the pressurised air is stored while some is utilised immediately. Even though it has been specified that the pressurised air may be utilised to drive turbines and electric generators to generate electrical energy, this is not to be taken to be restrictive. Other applications of the pressurised air produced are also conceivable. The invention relates to the exploitation of wave energy for the production of pressurised air.

C L A I M S

1. A device by a wave power plant, comprising at least one for instance bucket/shovel-shaped organ (1) which is responsive to the wave power and arranged to be displaced back and forth in the direction of motion thereof, and which is connected through an articulatedly linked connecting/piston rod to a first piston (5) which is supported, linearly reciprocating, in a first cylinder housing (4), and whereby the piston cylinder (5,4) transfers/transforms the wave energy into another form of energy, for example pressurised gaseous fluid which may be used to drive a turbine which drives a generator for the generation of electrical energy, c h a r a c t e r i z e d i n that said bucket/shovel-shaped organ (1) responsive to the wave power, is arranged in a channel-shaped wave house (2) which is sloping upwards in the direction towards said first piston (5), at least along the longitudinal extent of the wave house (2), and that the first cylinder housing (4) has valve organs (7b and 7a) arranged thereto, at either axial end, and a main valve (6) at the downstream end, said upstream valve organ (7b) being arranged to provide suction of gaseous fluid into the first cylinder housing and discharge of same behind the first piston (5), while said downstream valve organ (7a) is arranged to provide for supply of gaseous fluid to the active cylinder chamber of the first cylinder housing (4), the main valve (6) being arranged to be able to open at a predetermined pressure in the first cylinder housing (4) and to be able to release, at the opening, an amount of compressed gaseous fluid at said predetermined pressure.

2. A device according to claim 1, characterized in that the main valve (6) is provided with a pressure control (8) to set/adjust said predetermined pressure.

3. A device according to claim 1 or 2, characterized in that at the downstream end of the wave house (2) is mounted a mechanical shock absorber (3).

4. A device according to one or more of the preceding claims, characterized in that the bucket/shovel organ (1) responsive to the wave power is provided with a seal (11) at its rear end.

5. A device according to one or more of the preceding claims, characterized in that the first cylinder housing (4) also accommodates a second displaceable piston which divides the first cylinder housing into a curtailed first cylinder housing (4) of variable volume and a second cylinder housing (14) which has a valve organ arranged thereto, upstream of the second piston, and which communicates with the main valve (6) and said downstream valve organ (7a).

6. A device according to one or more of the preceding claims, characterized in that internally within the piston rod between the bucket/shovel organ (1), responsive to the wave power, and the first cylinder housing (4) is installed one or more third cylinder housings (24).

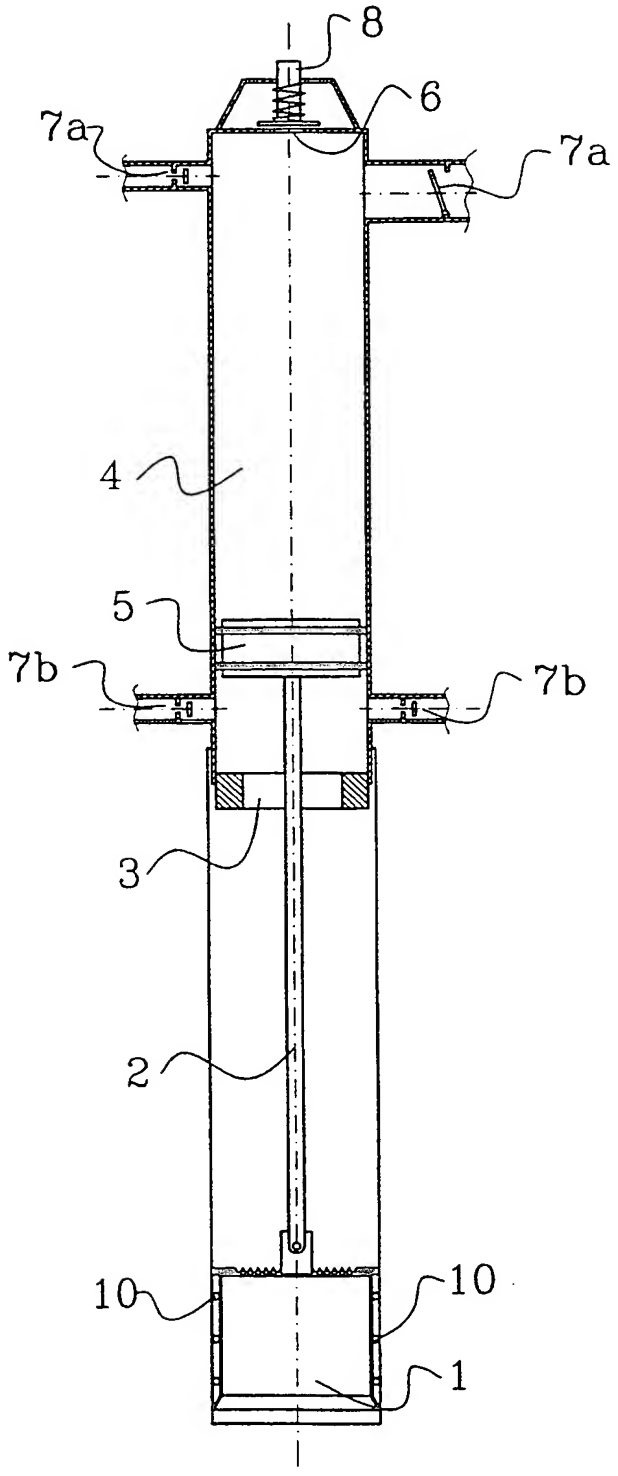

FIG. 1

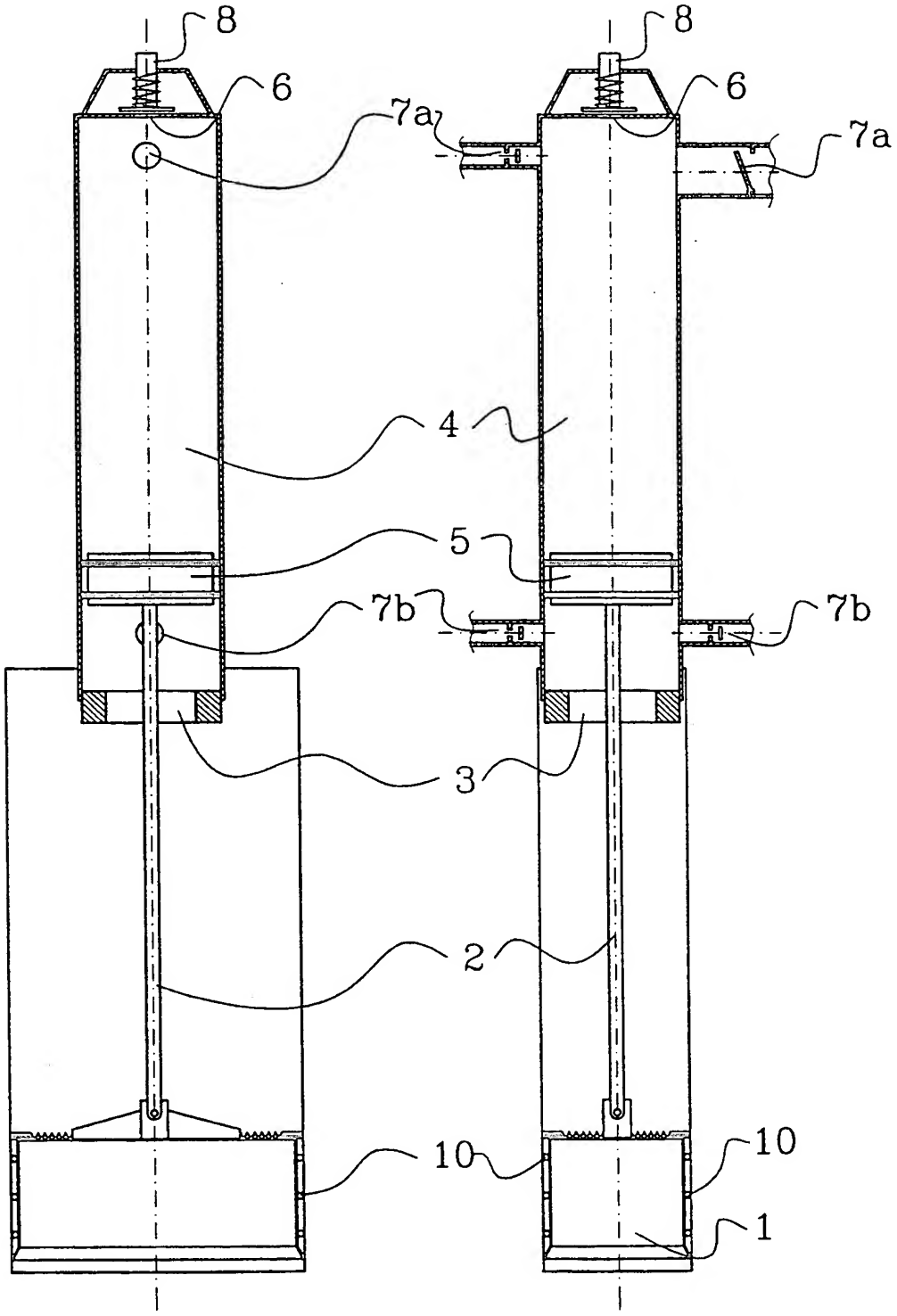

FIG. 2 FIG. 3

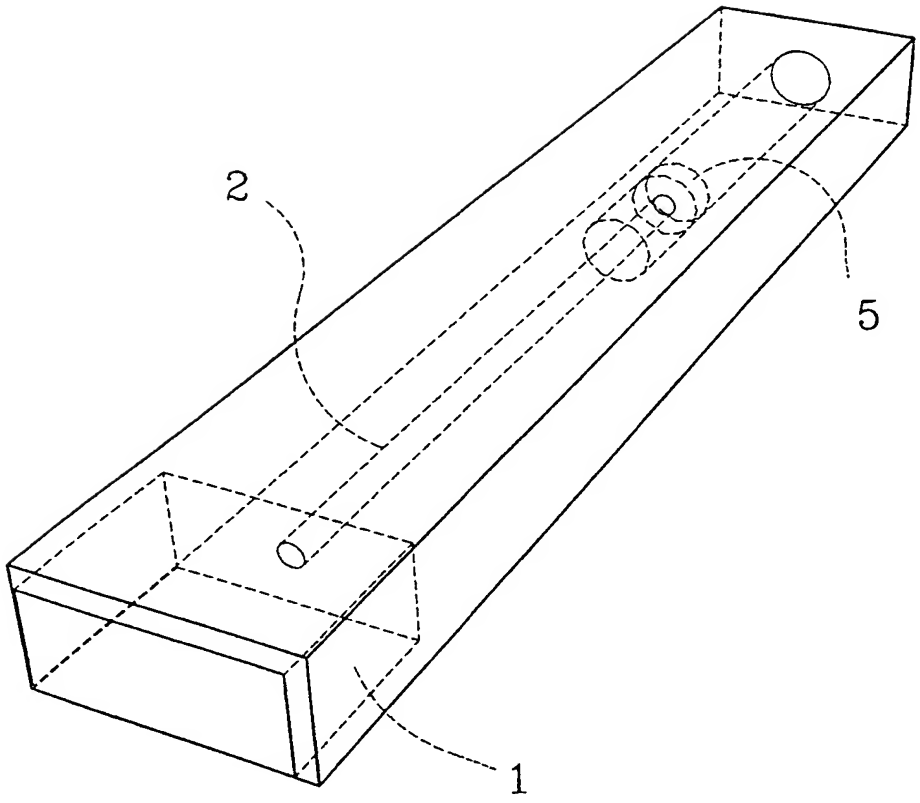

FIG. 4

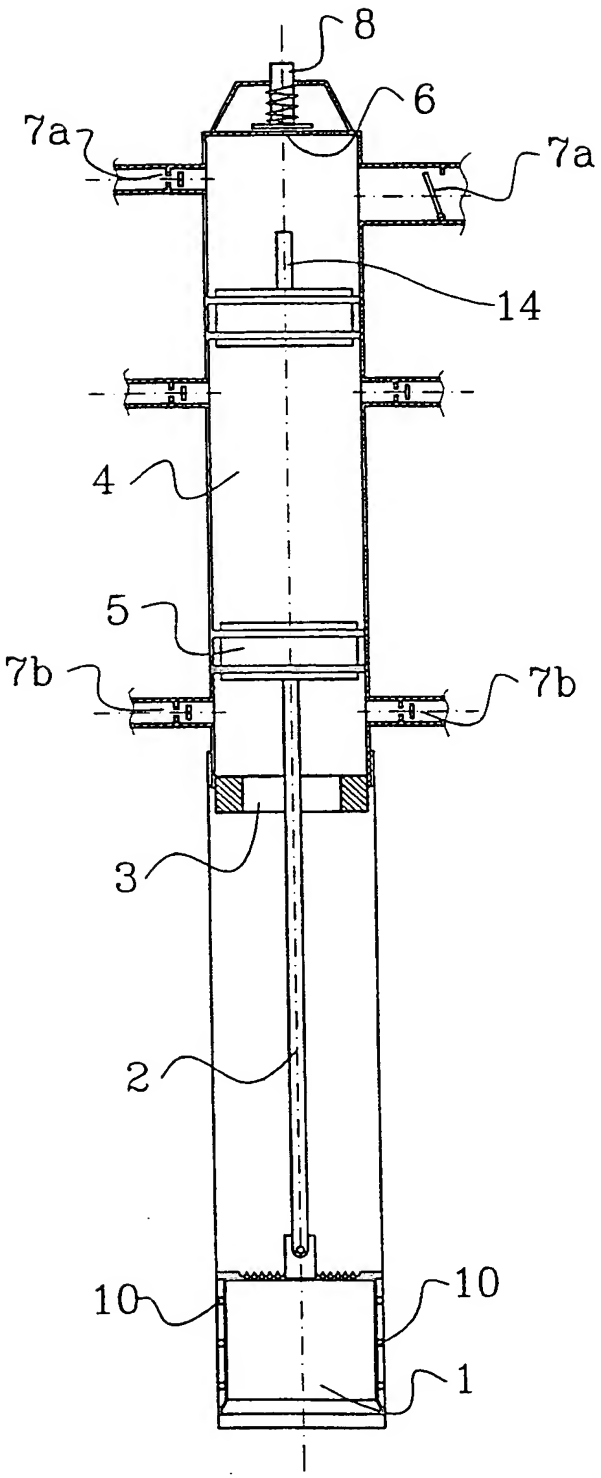

FIG. 5

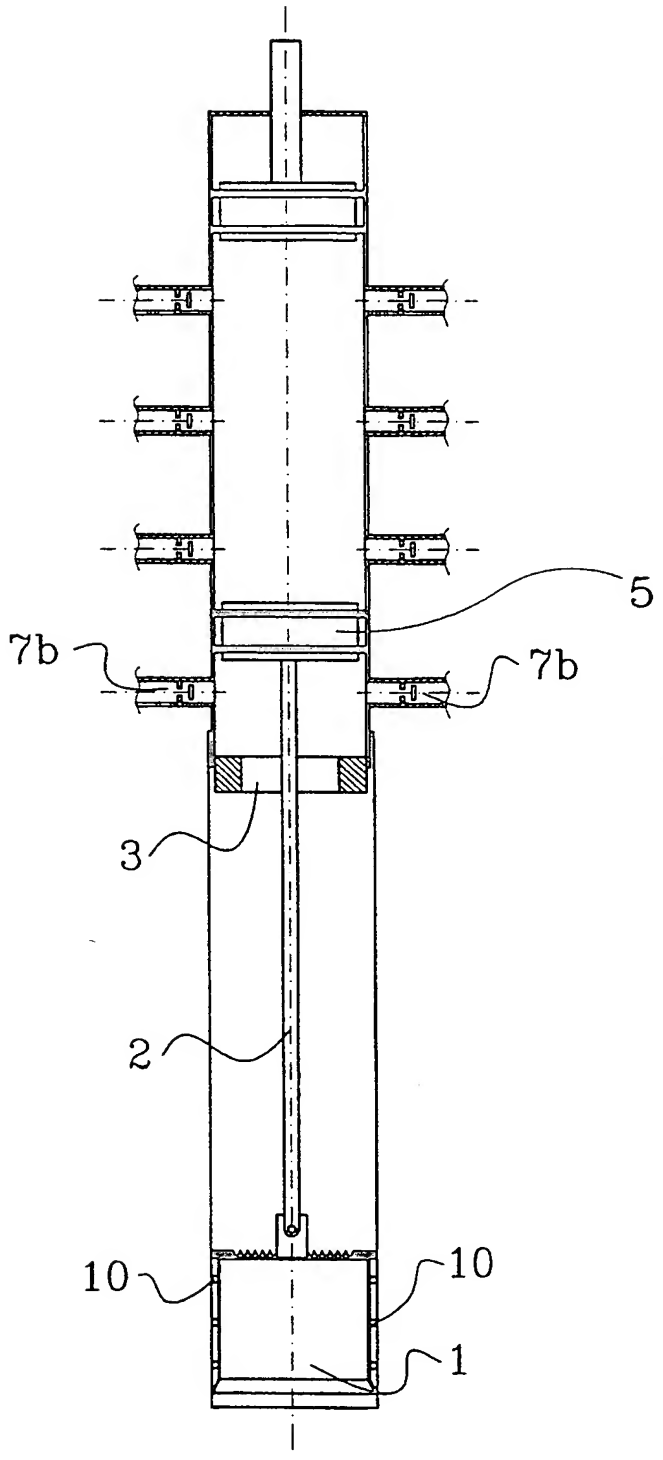

FIG. 6

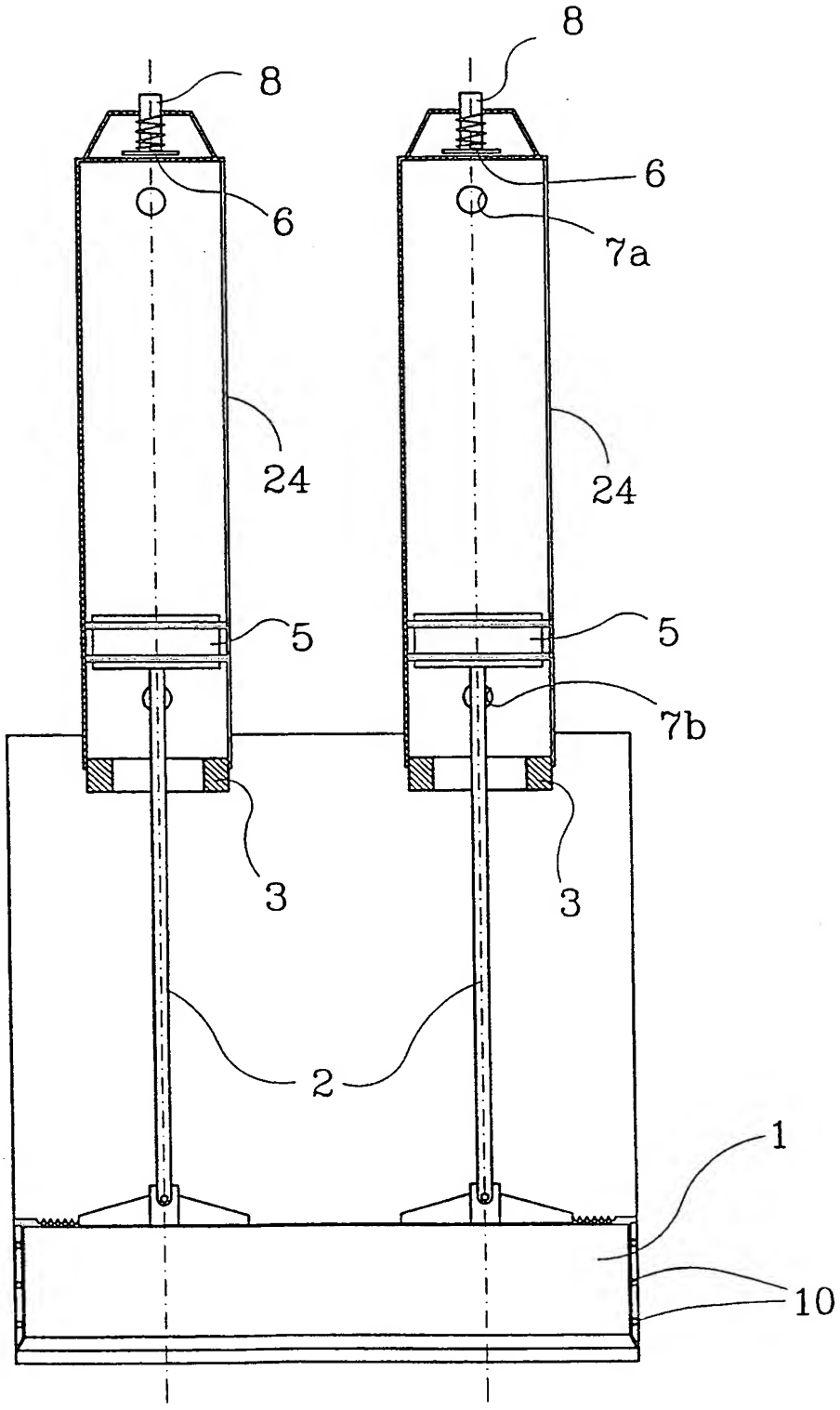

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 99/00222

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F03B 13/24, F03B 13/20
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B. FIELDS SEARCHED

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3268154 A (G. ARANYI), 23 August 1966 (23.08.66) --	1-6
A	US 2511705 A (D. FLETCHER ET AL), 13 June 1950 (13.06.50) --	1-6
A	US 1077509 A (R.A. REMIS), 4 November 1913 (04.11.13) --	1-6
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28/09/99

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3268154 A	23/08/66	NONE	
US 2511705 A	13/06/50	NONE	
US 1077509 A	04/11/13	NONE	
US 1073214 A	16/09/13	NONE	